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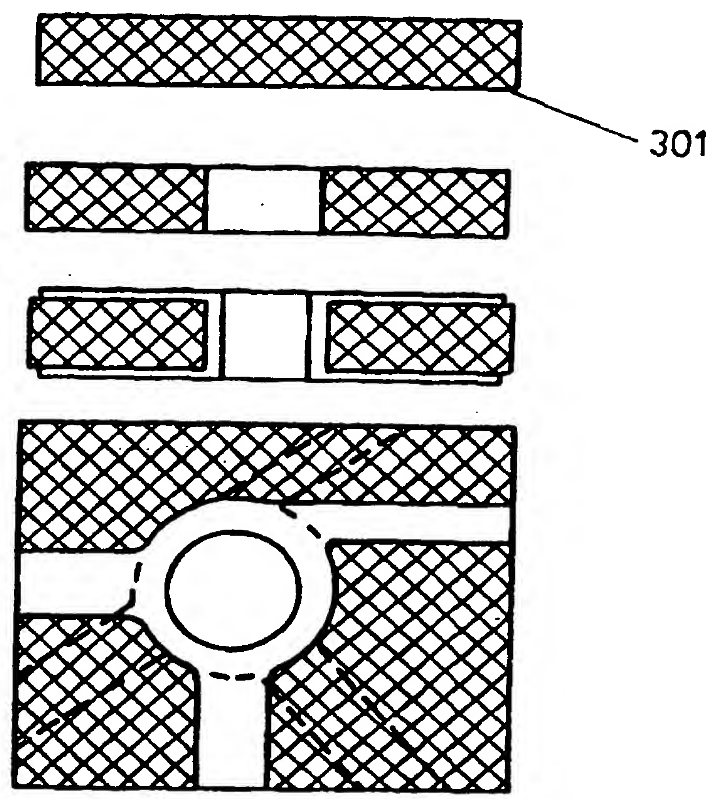
(57) Abstract

A method of producing an electrical circuit suitable for use as a fingerprint pattern digitizer. Conductive material is coated onto opposite sides of a plastics substrate from whence it is partially removed to define a pattern of conductive tracks. The opposite sides of the coated plastics device are connected by through vias coated with conductive material. The present invention in a further aspect provides a digitizing sensor comprising an array of individually actuable sensing cells on a deformable support.



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FINGERPRINT DIGITIZER WITH DEFORMABLE SUBSTRATE

This invention relates to electrical circuits and circuit elements. Preferred embodiments of the invention relate to digitizers comprising an array of individually actuable sensing cells for producing a bit map of a sensed pattern or feature. Such digitizers may be fingerprint sensors comprising an array of sensing cells each being defined by a contact switch.

Integrated circuit (IC) fabrication consists of a sequence of processing steps referred to as unit step processes that are, in the prior art, carried out on a slice of a semiconductor such as silicon which defines a substrate providing both mechanical support for the resultant IC and the basic material for producing the various desired circuit elements.

These unit step processes include the introduction and transport of dopants to change the conductivity of the semiconductor substrate, the growth of thermal oxides for inter- and intra-level isolation within the IC, the deposition of insulating and conducting films, and the patterning and etching of the various layers in the formation of the IC.

The known methods of IC fabrication use a semiconductor substrate. Such substrates must be produced under strictly controlled conditions and are therefore expensive.

Furthermore, the semiconductor substrate results in a rigid and brittle IC which is easily damaged and is incapable of effectively withstanding any significant applied bending moment. The semiconductor material is difficult to drill or cut. The processing of semiconductor materials such as silicon requires significant numbers of different processing steps (etching, masking etc) using toxic chemicals. This makes the processing of semiconductors and the disposing of the associated waste expensive and time consuming.

The present invention in a first aspect provides a method of fabricating an integrated circuit as defined in claim 1. Preferred features of the invention are defined in the claims dependent thereon.

The use of a substrate consisting of a plastics insulating material such as a polyimide, polyester, polyethylene, polystyrene, polyethylene terephthalate or ceramics, which is coated with a thin layer of a conductive material such as stainless steel, chromium or titanium results in a substrate which can be processed on both its primary and secondary sides to produce separate circuit elements. The choice of material deposited on the substrate depends on the desired electrical properties of the relevant portion of the circuit.

The plastics substrate can also be easily processed by, say, laser ablation, to establish conductive vias through the substrate for electrically connecting the electrical elements on opposite sides of the plastics substrate. Alternatively, capacitors may be produced by keeping

conducting elements separated by at least part of the thickness of the substrate. An additional advantage of the plastics substrate is that it is easier and cheaper to produce than a silicon substrate of the necessary purity.

The conductive through vias of a preferred embodiment of the invention also allow for more efficient convection of air through the device built according to the invention and therefore help to prevent the device over-heating.

EP-A-0459808 (G.E.C.- Marconi Limited - now assigned to Personal Biometric Encoders Limited) discloses a sensor construction producing a digitiser of high resolution capable of discerning a pattern of applied low differential pressures. This known digitiser is intended for use as a fingerprint sensor.

The prior art sensors such as that described in EP-A-0459808, comprise a non-deformable insulating substrate on whose upper surface alternate layers of conducting and insulating material are deposited (by plating or vacuum deposition) to produce a first set of parallel conductors separated from, overlying, and at right angles to a second set of parallel conductors.

Such prior art sensors are constructed using techniques similar to those used in the manufacture of integrated circuits on silicon slices (ie unit step processes).

A non-deformable insulating substrate is masked and then coated with metal to form a plurality of parallel row

electrodes forming a first set of conductors. Metal contact pads connected to the rows of electrodes by a thin film Nichrome resistor element are also deposited on the substrate.

An insulant such as polyimide is then deposited on top of the row electrodes, Nichrome resistors and associated contact pads. Vias are provided in the polyimide layer over each contact pad.

A second deposition of metal is then effected on this first polyimide layer to provide parallel column electrodes forming a second set of conductors orthogonal to the row electrodes. This second deposition of metal defines not only the column electrodes but also second contact pads, electrically integral with the column electrodes, and also provides a third set of electrically separate contact pads which extend through the first vias in the first polyimide layer into electrical contact with the first set of contact pads.

As well as being expensive and requiring a large number of processing steps to produce a digitiser, the use of a non-deformable insulating substrate renders the prior art sensors brittle and unsuitable for use on a flexible carrier such as a plastics card of the sort used for credit cards.

The present invention in a further aspect provides a digitising sensor comprising an array of individually actuable sensing cells on a deformable support.

The inventor has appreciated that contrary to what is indicated in the prior art and was previously thought to be the case, it is not necessary to support the sensor construction on a non-deformable support. Indeed, the use of a non-deformable support renders the sensor fragile and likely to break. A sensor having a deformable support, on the other hand, is tougher than the prior art sensors and able to withstand bending moments applied thereto. This renders the sensor according to the present invention particularly suitable for use on plastics card-type or smart card carriers.

The present invention in a further aspect provides a digitising sensor comprising an array of individually actuable sensing cells on a plastics support.

Preferred features of sensors embodying the present invention are defined in the dependent sensor claims.

The present invention also provides a method of making a sensor including a plastics support.

In a preferred embodiment of the method according to the invention, a deformable insulating sheet is coated with a conductive or semiconductive material, conductive or semiconductive material is removed from a first surface of the coated sheet to form a plurality of discrete first electrical elements, conductive or semiconductive material is removed from a second surface of the coated plastics sheet to form a plurality of discrete second electrical elements separated from and crossing the first conductors,

and conductive vias are provided through the deformable support, each conducting via being electrically connected to a second electrical element and a contact pad on the first surface of the deformable support.

The methods of the present invention allow one to produce an integrated circuit or sensor with a minimum of processing steps. The elimination of the need to remove significant quantities of semiconductor from the circuit or sensor substrate by a progressive series of masking, etching, cleaning, and drying or stoving (baking at high temperatures) steps greatly reduces the manufacturing costs of the sensor or integrated circuit.

In preferred embodiments of the invention concerned with a sensor including overlying separated sets of parallel conductors, the provision of the two sets of conductors on the upper and lower surfaces of the support, and the use of the coating on a plastics support to define these conductors obviates the need for a significant proportion of the masking and coating steps required in the prior art.

In a preferred embodiment of the invention, a deformable support or substrate is formed by an insulator having a coating of a conductor such as stainless steel. Sheets of insulants such as polyimide (e.g. Kapton - Trade Mark) are commercially available with a stainless steel coating. A deformable support made of polyimide coated with stainless steel is therefore readily and cheaply available. Furthermore, the use of a coating having stainless steel which has a significant resistivity obviates the need for

the deposition of separate resistor elements of Nichrome (or a similar material) as is necessary in the EP 0 459 808 device. This significantly reduces the costs associated with production of a digitising sensor.

In a preferred embodiment of the invention, a plastics substrate such as KALADEX (ICI trade mark for a polyester product), MYLAR, KAPTON (Du Pont trade marks for polyimide and polyethylene products respectively) or UPILEX (UBE trade mark for polystyrene product) is coated with a patterned layer of titanium on which gold is deposited.

Specific embodiments of the present invention will now be described, by way of example, and with reference to the accompanying drawings, in which:

FIGURE 1 is a schematic plan view of an array of sensing cells defining a sensor;

FIGURE 2 is a section through a portion of the line I-I illustrating the construction of a known fingerprint sensor;

FIGURES 3 and 4 are further views illustrating patterns of conductors on a substrate constructed in a known manner;

FIGURE 5 shows a fingerprint sensor including an electrical circuit embodying aspects of the present invention;

FIGURES 6a to 6h are a diagrammatic representation of a method embodying aspects of the present invention;

FIGURES 7a to 7d are a diagrammatic representation of an alternative method embodying the present invention ;

FIGURE 8 is a diagram illustrating a flow line production line suitable for implementing the method of figures 7a to 7d;

FIGURE 9 is a schematic plan view of the underside of a fingerprint sensor embodying aspects of the present invention;

FIGURE 10 illustrates an interdigitated configuration for paired contact pads suitable for use with sensors embodying aspects of the present invention; and

FIGURE 11 illustrates part of the pattern of conductive material on the substrate surface for connecting the actuated sensor to the associated circuitry.

Referring to Figure 1, a matrix of sensing cells 15 is defined by the cross-over points of a first set of parallel conductors 1 overlaid by a second set of parallel conductors 3 perpendicular to the first set of parallel conductors 1. Each of the first set of conductors defines an input bus and each of the second set of conductors defines an output bus. The input buses are connected to a power supply circuit and the output buses to a circuit containing the logic units for analysing the sensor output.

Each sensing cell 15 includes a contact pad 11 connected with one of the first set of conductors 1 and a second contact pad 13 connected to one of the second set of conductors 3. Current/information flows from the input bus conductor 1 of an activated cell to the output bus of the cell 15 when the two contact pads 11,13 are electrically connected by a contact bridge brought into contact with the two pads 11,13 in response to pressure applied to the sensor above the respective sensing cell.

Referring to figure 2, the conductors 1,3 of a known fingerprint sensor are supported on a substrate 5 and the sensor also comprises a resiliently deformable membrane 7 supported above the conductors 1,3 and having conductive tiles 9 on its lower surface.

Deformation of the resilient membrane 7 by, say, the ridge of a fingerprint pattern brings one of the conductive tiles 9 into contact with contact pads 11, 13 associated respectively with, one of the first conductors 1 and one of the second conductors 3 at the cross-over point of the conductors so as to bridge the gap between the two conductors. Current/information can then flow from the input bus to the output bus via the contact or conductive tile 9. Each cell has an associated resistance resulting in a potential drop across a cross-over point bridged by the conductive tile.

In the embodiment of the invention illustrated in figure 3, the array of paired contact pads 11,13 and the associated conductors 1,3 forming the input and output

buses, is supported by a deformable support or substrate. It has been found advantageous to replace the undeformable substrate of the prior art devices with a deformable substrate made from a flexible material such as KALADEX (ICI trade mark for a polyester product), MYLAR, KAPTON (Du Pont trade marks for polyimide and polyethylene products respectively) or UPILEX (UBE trade mark for polystyrene product).

The fingerprint digitizer (see figure 5)of embodiments of the present invention is preferably incorporated into a card-like assembly which includes a connector 231 for inserting into a card receiving port so as to allow the transfer of information between the card and a data processing facility or similar, connected to the card receiving port. The card assembly has an integral memory and data processing facility 232 as well as a sensor or digitising portion. Suitable cards may be modified PCMCIA (Personal Computer Memory Card International Association) cards.

In the embodiment of figure 5, a plastics substrate 201 having a pattern of conductors on its upper and lower surfaces is held between two printed circuit boards 220, 221 each having integral ASICs 222 (application specific integrated circuits). The inner surfaces of the printed circuit boards each have contacts which, in the assembled sensor, connect the ASICs with contact portions 223 on the plastics substrate 201. As will be described below these contact portions are themselves connected to the digitizer electrodes/conductors formed by the overlying conductor

arrangement having mutually perpendicular sets of parallel spaced electrodes.

One of the ASICs is a driver circuit which supplies current/information to the first, input bus, set of parallel conductors or electrodes of the digitizer matrix, and the other ASIC is a sensing circuit connected to the second, output bus, set of parallel conductors or electrodes so as to receive any current/information which flows from the driver circuit on operation by the presence of a fingerprint epidermal ridge of the switches comprising the digitizer. The ASICs, on-card data processing and on-card memory combine to produce a signal representative of the identifying features of a sensed fingerprint pattern.

A first active surface of the sensor substrate includes a pattern of conductive material defining a sensing or digitising area 230 containing a first set of parallel electrodes or conductors (forming input buses), which are connected by conductive tracks 224 to contact portions 223 for connecting the first set of electrodes to the contacts of the driver circuit located on the inner surface of one of the printed circuit boards. The second opposite surface of the sensor substrate includes a pattern of conductive material defining a second digitizer area corresponding to that on the opposite substrate surface and having a second set of parallel electrodes or conductors perpendicular to the first set. The pattern of conductive material on the second surface also defines conductive tracks 224 and contacts 223 for connecting the second set of electrodes

(output buses) to the contacts of the sensing circuit on the inner surface of one of the printed circuit boards.

The driver and sensing circuits or ASIC s may be arranged the other way round so that it is the driver circuit which is on the active side of the coated substrate.

The substrate includes an array of vias through the substrate from its first to its second surfaces. Each via corresponds to a cross-over point of the two sets of mutually perpendicular parallel electrodes or conductors 1,3. Those electrodes on the active or sensing surface of the substrate include a set of first contact pads 11 at each cross-over point, and those electrodes on the opposite substrate surface are electrically connected through the vias with a set of second contact pads 13 at each cross-over point, and separated from the respective first contact pads of each cross-over point. The first and second contact pads and via associated with each cross-over point define an electrical resistance associated with each cross-over point.

The portion of the substrate not sandwiched between the two printed circuit boards includes the sensing or digitizer portion 230 of the patterned plastics substrate. This portion of the substrate is folded over and fixed to the card assembly such that the sensing area defined by the paired contact pads 11,13 (see figure 10) is exposed on the surface of the card assembly. A resilient membrane defining contact bridges is fixed to the card assembly over the sensing area so as to define digitizer switches in

combination with the sensing area contact pads. Contact bridges are brought into contact with the paired contact pads 11,13 of cross-over points on deformation of the resilient membrane in response to the presence of contact with an epidermal ridge so as to connect the paired first and second contact pads of cross-over points corresponding to the location of fingerprint epidermal ridges.

The card assembly may include a protective sheath such that only the sensing area of the folded substrate is exposed. The resilient membrane may also be attached to the protective sheath.

A possible deformable membrane construction 7 having the contact bridges is described in our co-pending application no. filed together with and on the same day as this application. The membrane 7 is of a material such as MYLAR or KAPTON (trade marks) and, at a thickness of less than 12 μm (preferably about 3 μm), has the necessary properties of strength and deformability. On its surface confronting the matrix, the membrane 7 has a continuous conductive layer 17 of a doped polyaniline copolymer having a sheet resistivity of 30 $k\Omega/\square$. This layer 17 can be coated or sprayed onto the MYLAR or KAPTON sheet before this is attached to the sensor. The conductive layer 17 is not connected to a voltage or potential source other than when it connects to electrodes 1, 3 and current flows through it across the gap between the contact pads 11, 13.

The use of a sensor having a flexible substrate and a flexible upper membrane improves conformance of the sensor

membrane to the contours of an applied fingerprint and allows for accurate measurement of a pattern.

In addition plastics substrates are considerably easier and cheaper than silicon and rigid substrates to both produce in the first place, and subsequently process to produce electrical circuits and circuit elements.

The use of a sensor having a plastics substrate allows one to significantly reduce the cost of producing a digitizer comprising an array of sensing cells which respond to the presence or absence of a fingerprint epidermal ridge. The plastics substrate is considerably cheaper than the silicon substrates of the known digitizers. It is also considerably easier to process a plastics substrate to produce the mutually perpendicular sets of overlying and separated electrodes or conductors than to manufacture a digitizer having a silicon or semi-conductor substrate as is proposed for the known fingerprint digitizers.

It is desirable to be able to put fingerprint sensors on a portable carrier such as a plastics credit card (or similar plastics carrier) or a smart card such as a PCMCIA card. Fingerprints are difficult to forge and fingerprint sensors are therefore a useful form of identification in any transaction authorising environment. Consequently, fingerprint sensors whose circuitry is suitable for locating on portable cards are particularly advantageous.

Portable plastics cards and smart cards require a degree of flexibility so as to cope with the bending moments

and stresses associated with their transport, storage and use. Plastics cards will typically accommodate a bending of up to about 90° and fingerprint sensors mounted on a plastics card such as a credit or charge card should therefore be able to cope with the bending. Although mounting the sensor towards one edge of the card reduces the bending which the mounted sensor needs to cope with, the mounted sensor may still be subjected to bending moments sufficient to damage a rigid sensor.

A solution has been to mount a rigid silicon-based sensor on a flexible mounting which absorbs the strain associated with bending of the plastics carrier.

The use of a thin film of a deformable plastic such as a polyimide, polyester, polystyrene, or polyethylene terephthalate coated with a thin layer of, for example a conductive metal such as gold to produce the circuit elements, results in a sensor which can be bent through very significant angles (up to about 180°) without being damaged. Although this degree of flexibility is not required for all embodiments of the invention, some embodiments of the present invention allow a sensor approximately 10-15 mm square mounted towards the edge of a plastics carrier approximately 8-9 cm (standard credit cards are 8.5 cm by 5.5cm) to flex sufficiently so as to bend together with a plastics credit card bending through angles of up to 90° without damage to the sensor.

The plastics substrate suitable for in the invention must be capable of withstanding the likely mechanical

stresses and environmental conditions to which it is likely to be subjected, as well as have the necessary electrical and machinability properties.

Polyethylene terephthalate or polyimide sheets 10 to 50 μm thick have been found to be highly suitable as substrates for fingerprint digitisers as they can be metallised and subsequently machined or etched by established processes, and they are able to meet the necessary performance parameters.

Particularly desirable material properties of substrates for a fingerprint digitiser circuit are found to be as follows:

a) a high tensile strength with a Youngs Modulus in the range 3000 to 6000MPa; 5500 MPa is a preferred value;

b) low thermal shrinkage i.e. dimensionally stable throughout the temperature range -10°C and 250°C. A glass transition temperature greater than 200°c is preferred;

c) plastics sheet should be flexible, whilst easy to handle without causing wrinkles. A thickness of 25μm is suitable for KAPTON or MYLAR substrates.

d) Plastics should be easy to machine using conventional machine tools, and preferably also lasers.

e) good resistance to hydrolysis - ideally less than 0.8% in twenty-four hours at 25°C;

f) good resistance to corrosive agents such as strong acids and alkalis, sodium hydroxide, acetic acid and similar;

g) high sheet resistance (10^{16} Ω/□;

h) high contact and bulk resistance (volume resistivity 10^{18} Ωcm;

i) relatively high melting point - 125 to 250° - preferably 250°C.

In order to maximise the life of the fingerprint sensor or electrical circuit, the plastics properties should be stable throughout the circuit's intended life.

Methods of manufacturing electrical circuits will now be described with reference to figures 4 to 6.

In the fingerprint sensor embodiment of Figure 6 a 36 μm polyimide sheet 101 is covered with a 0.01 μm stainless steel coating 102 (see Fig.6a). A matrix of 10 μm diameter holes 103 is then made through the sheet by, for example laser ablation (see Fig.6b). The laser power and exposure depends on the thickness of the steel coating and polyimide sheet. The holes 103 are made at a density corresponding to the desired resolution of the fingerprint sensor. The resolution of the sensor can also be influenced by staggering or offsetting alternative rows of vias. A hole 103 is made for each sensing cell in the sensor array. For a uniform via configuration with vias defining the corners of squares, the inter hole pitch is approximately 100 μm for a 100 μm cell and approximately 50 μm for a 50 μm sensing cell.

The holed sheet is then uniformly covered with a 0.5 μm copper layer 104 by, say, a low build electroless process (see figure 6c). This establishes conductive vias 105 between the coated conductive upper 106 and lower 107 surfaces of the sheet.

Interdigitated (see figure 10) upper (or active) surface cell contacts 108 and row buses 109 are then configured on the upper surface by, say, laser ablation (see fig. 6d). One contact of each cell is connected to the conductive via and the other separate contact is connected to an associated row bus 109. The lower surface 107 of the sheet is then processed by, say, laser ablation, so as to be configured to form the cell resistors 116 and column buses 110; one column bus 110 and one cell resistor 116 being connected to each conductive via 105 (see figures 6e and 9).

The cell resistors 116 are then masked with a masking material 121 before both the upper and lower surface circuits defined by the remainder of the stainless steel and copper layer are electroplated with gold 120 so as to improve their conductivity (see figs. 6f and 6g). The cell resistors 116 are not coated as a high resistance relative to the gold contact resistances is desired. The use of gold contact pads results in a very effective contact switch, particularly when used in combination with contact bridges made from a conductive polymer such as a doped polyaniline copolymer. Other high conductivity materials (eg, silver) may be used in lieu of gold although gold has been found to be particularly effective. Similarly, the stainless steel

coating may be replaced by a coating of another conductive metal such as chromium or titanium. The combination of a gold layer on titanium has been found to be particularly advantageous.

Finally (see figure 6h) the mask resist is retrieved from the cell resistor 116 and the sheet is etched with, say, an ammonium based solution to remove the electroless copper from the resistor. The resistance of the cell resistor 116 is then defined by the electrical properties and dimensions of the steel only.

Referring to figure 9, the column bus 110 associated with each cell is connected with the respective conductive via 105 by the cell resistor 116

In the alternative method shown in figures 7 and 8, a thin sheet 301(approximately 20μm - although it is possible to use thinner sheets, this leads to handling problems) of a suitable plastics material such as KAPTON, MYLAR, UPILEX or KALADEX forms the substrate or support.

An even array of vias 303 (see figure 7b) is drilled through the plastics sheet. This has been done by laser ablation using approximately 300 shots of a laser of 400 mJ/cm^2. Use of a more powerful laser would allow one to reduce the necessary exposure. As discussed below, the dimensions and shape of the vias are important as the surface area of the inside of the vias determines the electrical resistance of each sensing cell. In a preferred embodiment the via is produced by drilling overlapping

circular holes such that each via is substantially oval or bean-shaped and is about 12.5 μm by 22.5 μm

The surfaces of the drilled plastics sheet are then cleaned. This can be done by scanning with a low intensity laser (single shot of approximately 200 mJ/cm²). This laser cleaning removes debris and produces a non-glossy or matt finish on the substrate surface. This finish aids the subsequent coating of the substrate with a conductive material.

The cleaned drilled plastics substrate is then coated (see figure 7c) with a thin (approximately 500 Å) layer of titanium. The titanium is sputtered onto the substrate by, for example, ion assisted sputtering. The sputtering is done at a variety of angles to the substrate surface so as to ensure that the surfaces inside the vias are entirely coated with titanium.

A thin layer of gold (approximately 0.1 μm or 1000 Å) is then sputtered onto the titanium (see figure 7c) to produce a metallised substrate with an outer layer of gold on an inner layer of titanium which is itself fixed to the plastics substrate. As with the titanium coating the direction of sputtering is varied to ensure an even layer extending through the via. The thickness of the gold and/or titanium layers can be controlled by varying the sputtering time. The intermediate layer of titanium results in a better adhesion of the gold to the substrate. Other possible intermediate layering materials include stainless

steel and chromium. Titanium is however found to be particularly advantageous.

A pattern of conductive portions forming elements of an electrical circuit is then formed on the substrate surfaces, by removing conductive material from each by, for example, laser ablation (see figure 7d). A suitable laser exposure is five shots of a 200 mJ/cm^2. The exposure time and number of shots would be varied for lasers of different power. The pattern of conductive portions defines the two sets of electrodes and corresponding contact portions of the digitizer portion, as well as the connections for connecting the digitiser to the driving and sensing circuits or ASICs. The resistance of each sensing cell is essentially defined by the resistance of the thin layer of gold in the via corresponding to each sensing cell. A 1000Å (or 0.1 μm) thick layer in a via 12.5 μm by 22.5 μm results in a cell resistance of approximately 16 $k\Omega$.

Figure 8 illustrates a flow line production method implementing the method of figure 7.

Although the method described above uses titanium and gold, it is possible to substitute these for stainless steel or chromium, and silver respectively. Furthermore, although the methods described above relate to the production of conductors, it is possible to use the same method with different via configurations or coating materials to produce other electrical elements. Capacitors may be produced by having vias which do not extend right through the substrate so that one produces elements comprising conductive portions

separated by a small insulating or dielectric gap. Other electrical components may be made by depositing the appropriate materials (eg semiconductors) on the substrate.

The techniques described above can also be used to produce electrical components such as integrated circuits.

A 100 μm layer of a plastics insulant such as a polyimide (MYLAR, polyester (KALADEX), polystyrene (UPILEX), polyethylene or polyethylene terephthalate (KAPTON) having a melting point of about 500° or higher, coated with a thin conductive layer (approximately 0.01 μm thick) of a conductor such as stainless steel, titanium or chromium can be processed by laser ablation to produce conductive tracks.

Semiconductor material such as silicon is then deposited on selected portions of both upper and lower surfaces of the substrate for subsequent processing to form electronic devices defining an integrated circuit on both sides of the substrate. The semiconductor material may be deposited by any of the established processes such as diffusion, vacuum deposition or epitaxy. In the preferred embodiment of the invention concerned with the manufacture of integrated circuits, the silicon for producing the electronic components is deposited only where it is required and the electronic components are essentially manufactured at their required positions on the substrate having the conductive tracks. This embodiment obviates the need for the cumbersome removal of semiconductor material using toxic

chemicals associated with the known methods of manufacturing integrated circuits.

The integrated circuit elements on opposite sides of such a device are connected via the conductive through vias established in the substrate.

An integrated circuit according to the present invention makes use of both sides of the substrate and it is particularly advantageous to provide a circuit comprising a number of inter-connected double-sided integrated circuits according to the invention arranged on top of each other. Each integrated circuit or surface of an integrated circuit can be made to perform a particular function and a collection of such ICs collated so as to form a data processing circuit.

Integrated circuits or electrical circuits, and/or electrical elements embodying the present invention may also be produced on plastics substrates using any of the known coating methods including immersion processes such as the ATOCHEM process sold by Englehard-CLAL.

CLAIMS:

1. A method of making a digitiser including providing a deformable support and forming an array of individually actuable sensing cells thereon.

2. A method of making a digitiser including providing a plastics support and forming an array of individually actuable sensing cells thereon.

3. A method according to claim 1 or claim 2 including providing an insulating support;

providing holes extending through or partly through the insulating support;

coating both surfaces of the support with a conductive material;

removing conductive material from a first surface of the coated support to form a plurality of first conductive portions;

removing conductive material from a second surface of the coated support to form a plurality of second conductive portions separated from and crossing the first conductive portions at locations corresponding to the location of the holes, wherein an electrical coupling may be established between respective first and second conductive portions through the holes on actuating the corresponding portion of the digitiser.

4. A method according to claim 3, wherein the holes extend through the support.

5. A method according to claim 3, wherein the holes only extend partly through the support.

6. A method according to any preceding claim including: providing a support comprising a thin sheet of a plastics material such as a polyimide, polyester, polystyrene, polyethylene.

7. A method according to claim 6 including: providing a support comprising a thin sheet of polyethylene terephthalate.

8. A method according to any preceding claim wherein the conductive material is stainless steel, titanium or chromium.

9. A method according to any preceding claim in which a second layer of a different conductive material is coated onto the first coating of conductive material.

10. A method according to claim 9, wherein the second layer of conductive material has a higher conductivity than the first layer.

11. A method according to claim 10 wherein the first layer is a thin layer of titanium and the second layer is a thin layer of gold.

12. A method according to any of claims 1 to 9, wherein the second layer is of a semiconductor.

13. A method of making an integrated circuit comprising:

providing an insulating substrate;

coating opposite faces of the substrate with a layer of conductive material; and

removing portions of the conductive layers to define conductive tracks on the surface of the substrate.

14. A method according to claim 13, wherein the substrate is deformable.

15. A method according to claim 13 or 14, wherein the substrate comprises a thin sheet of a plastics material such as a polyimide, polyester, polystyrene, polyethylene.

16. A method according to claim 15 wherein the substrate comprises a thin sheet of polyethylene terephthalate.

17. A method according to any of claims 13 to 16 wherein the conductive material is stainless steel, titanium or chromium.

18. A method according to any of claims 13 to 17 in which a second layer of a different conductive material is coated onto the first coating of conductive material.

19. A method according to claim 18, wherein the second layer of conductive material has a higher conductivity than the first layer.

20. A method according to claim 19 wherein the first layer is a thin layer of titanium and the second layer is a thin layer of gold.

21. A method according to any of claims 13 to 18, wherein the second layer is of a semiconductor.

22. A method according to any of claims 13 to 17 comprising the further steps of:

making conductive through vias connecting the coated opposite faces of the substrate;

depositing semiconductor material on the opposite substrate faces; and

processing the deposited semiconductor material to produce electrical or electronic devices.

23. A method according to any preceding claim where the conductive material and insulating substrate are processed using a laser.

24. A digitiser comprising an array of individually actuable sensing cells formed on a deformable support.

25. A digitiser comprising an array of individually actuable sensing cells formed on a plastics support.

26. A digitiser according to claim 24 or claim 25 wherein the support comprises a thin sheet of a plastics material such as a polyimide, polyester, polystyrene, polyethylene.

27. A digitiser according to claim 26 wherein the support comprises a thin sheet of polyethylene terephthalate.

28. A digitiser according to any of claims 24 to 27, including conductive tracks coated onto the support.

29. An integrated circuit comprising a plurality of electrical elements formed on a deformable support.

30. An integrated circuit comprising a plurality of electrical elements formed on a plastics support.

31. An integrated circuit according to claim 29 or claim 30 wherein the support comprises a thin sheet of a plastics material such as a polyimide, polyester, polystyrene, polyethylene.

32. An integrated circuit according to claim 31 wherein the support comprises a thin sheet of polyethylene terephthalate.

33. An integrated circuit according to any of claims 29 to 32, including conductive tracks coated onto the support.

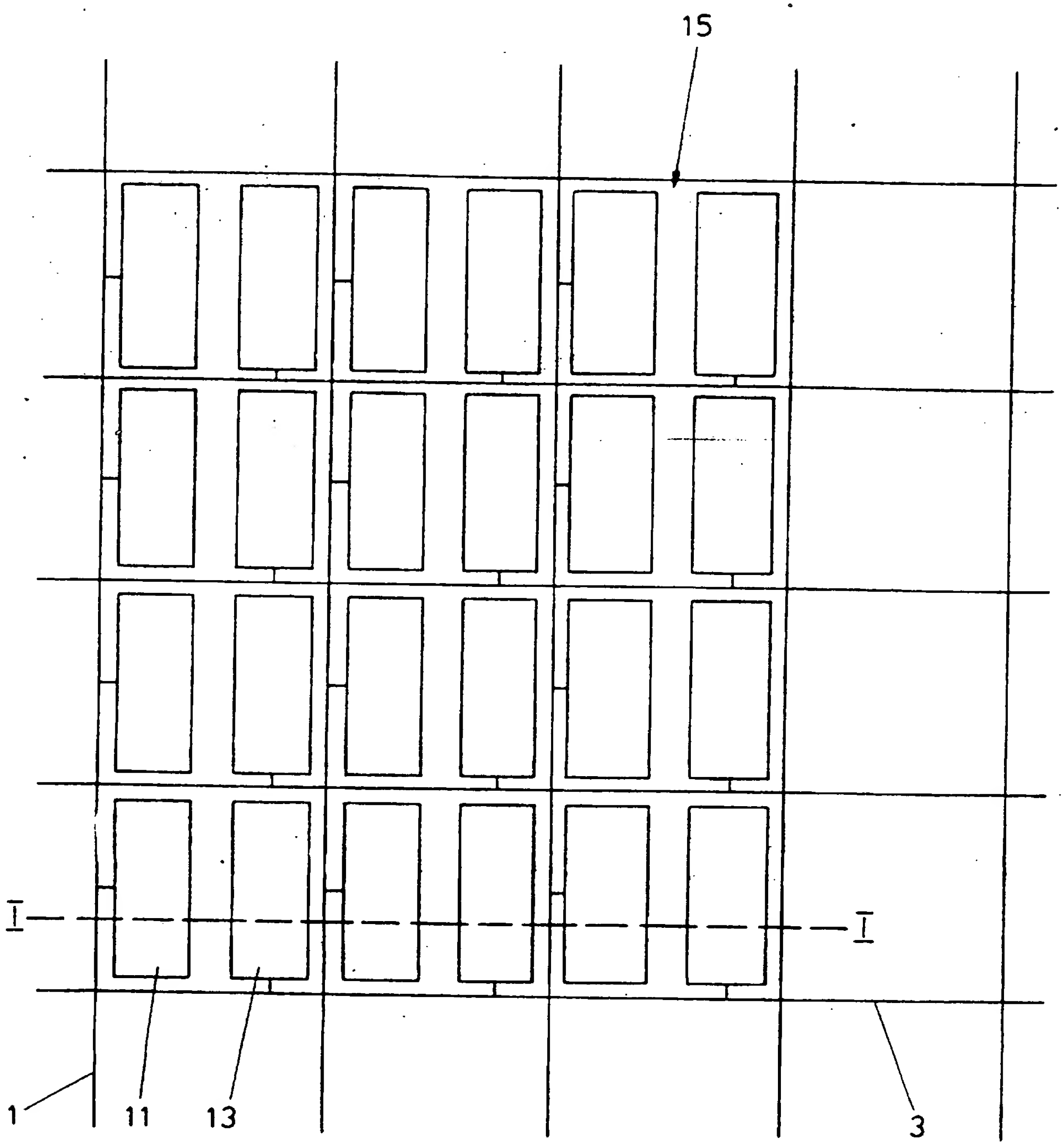

FIG. 1

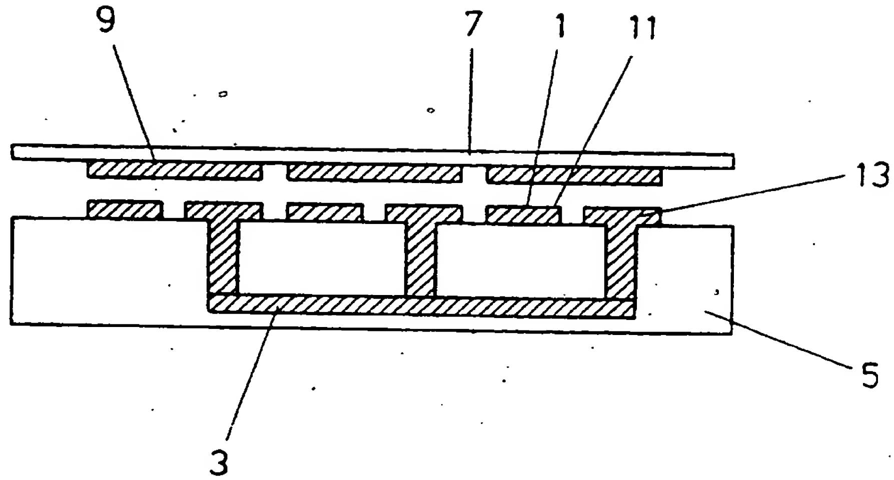

FIG. 2

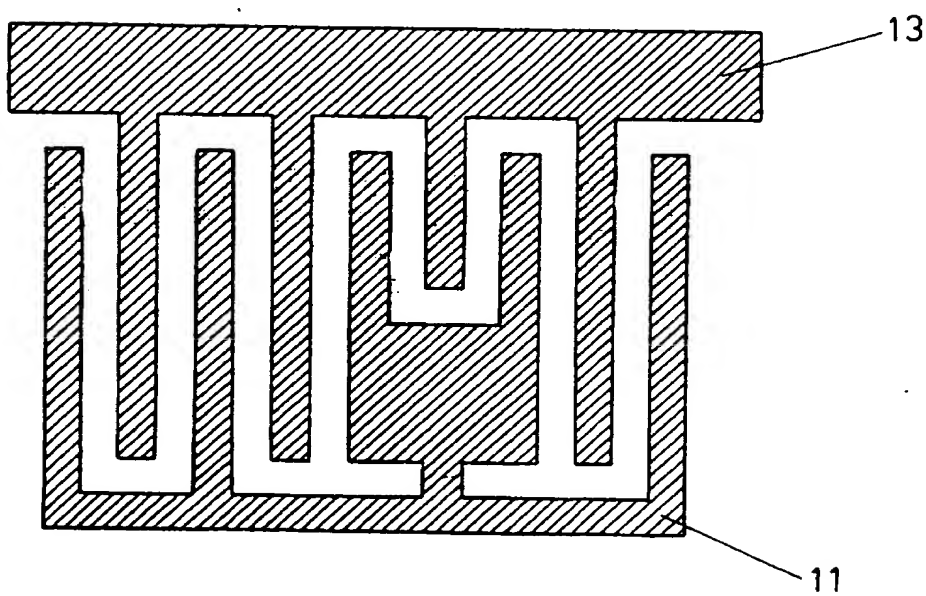

FIG. 10

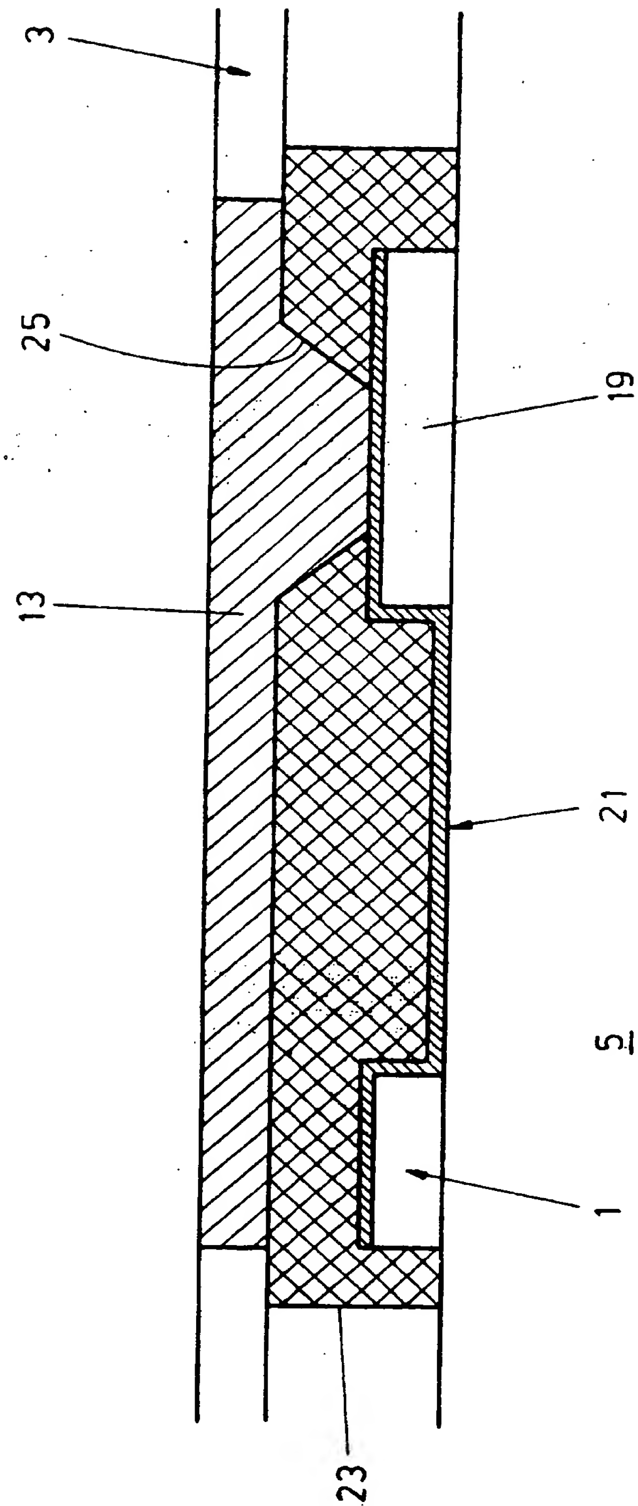

FIG. 3

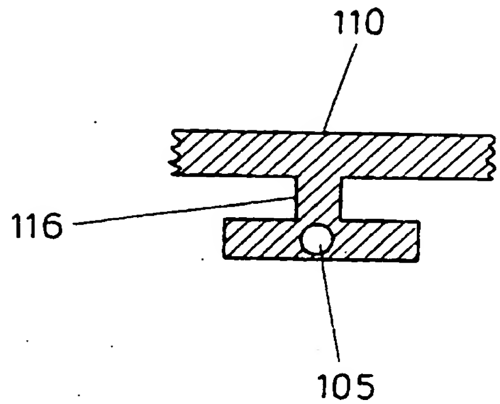

FIG. 9

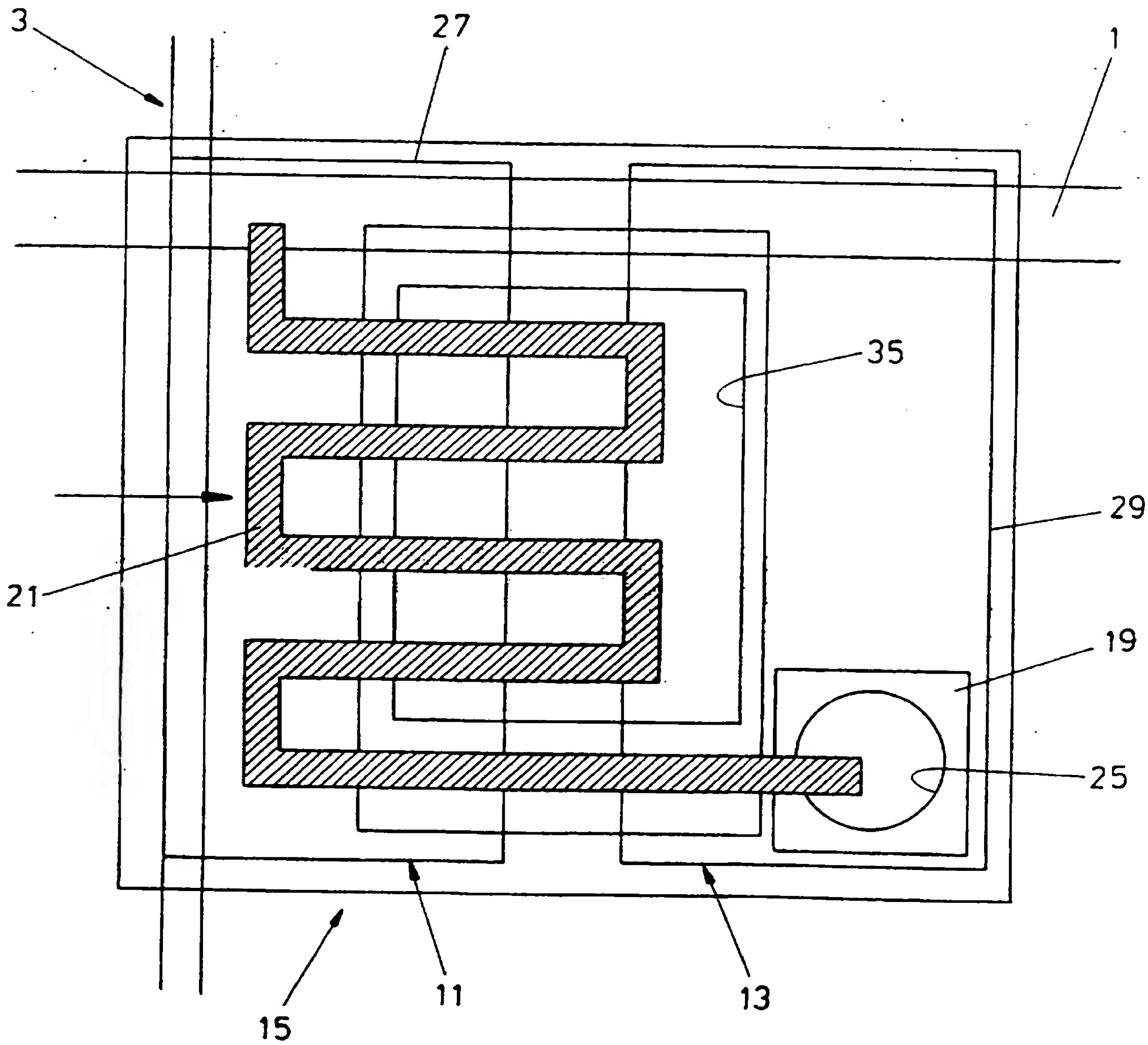

FIG. 4

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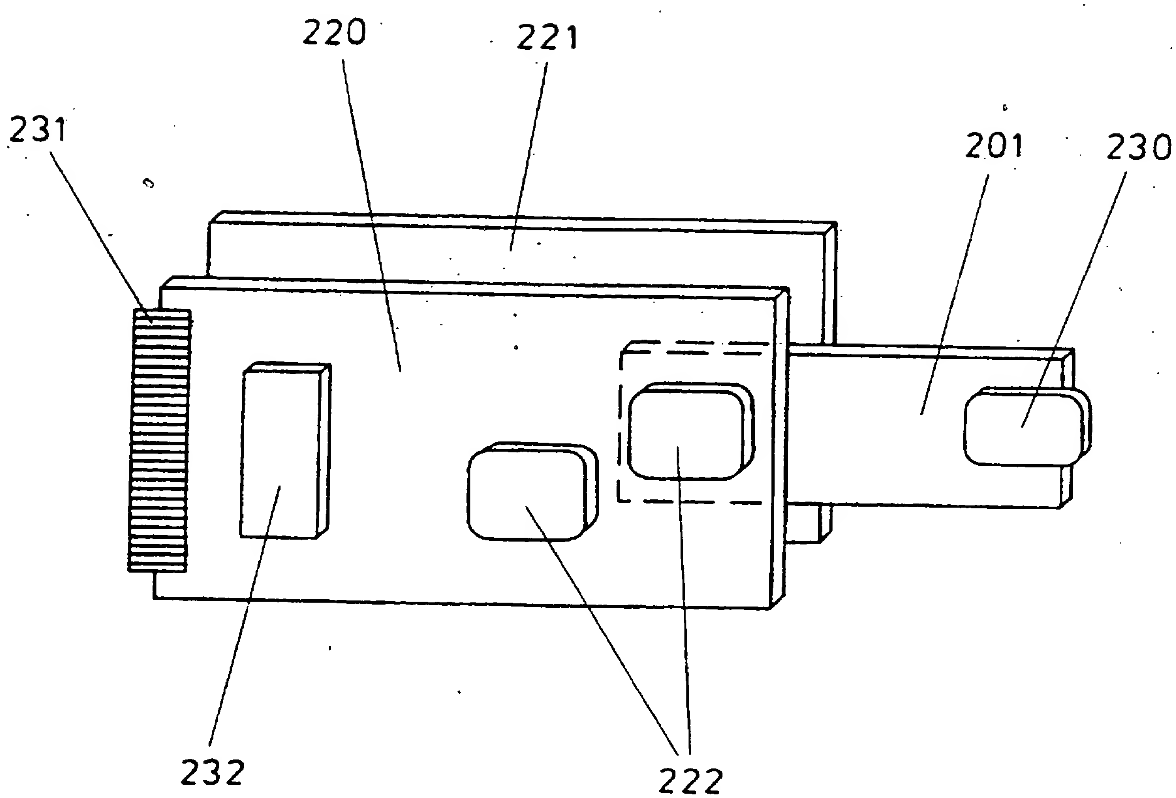

FIG. 5

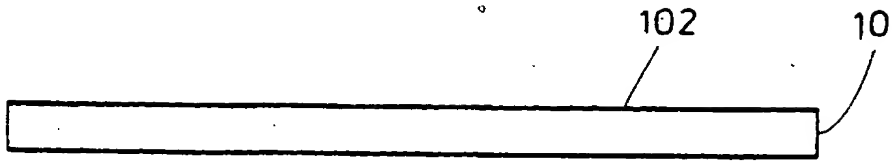

FIG. 6a

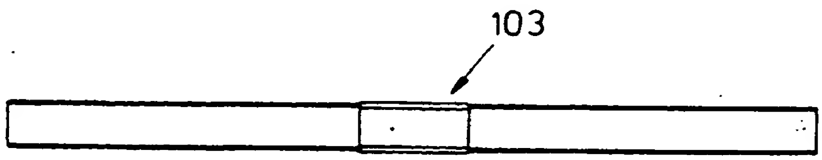

FIG. 6b

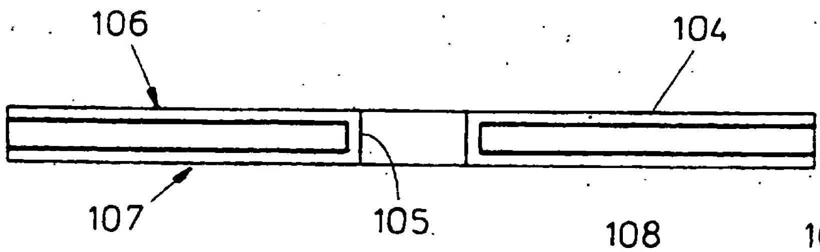

FIG. 6c

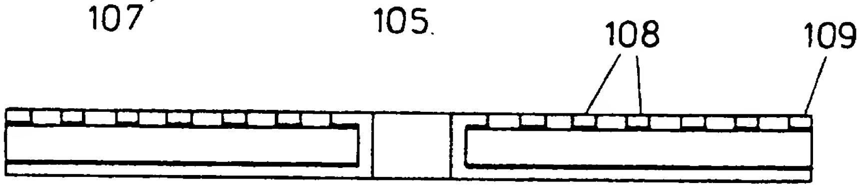

FIG. 6d

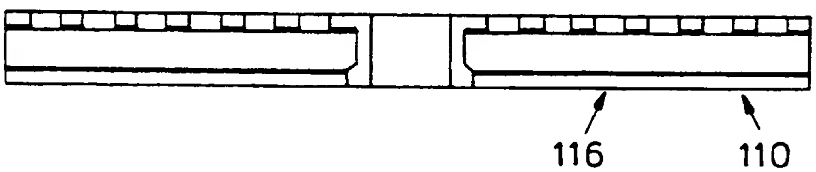

FIG. 6e

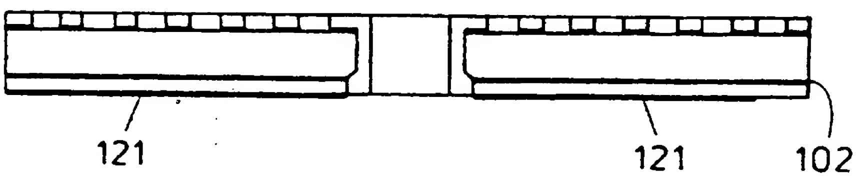

FIG. 6f

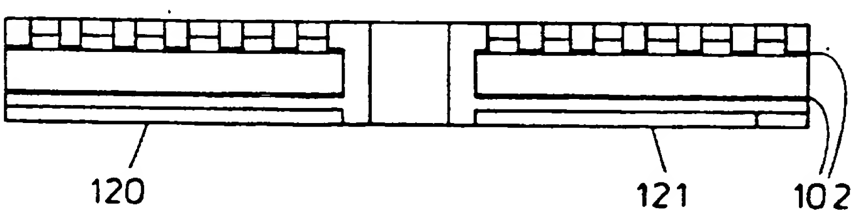

FIG. 6g

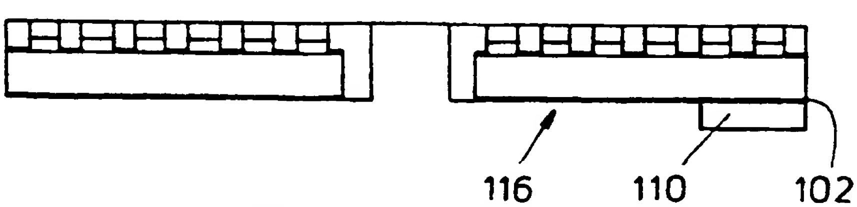

FIG. 6h

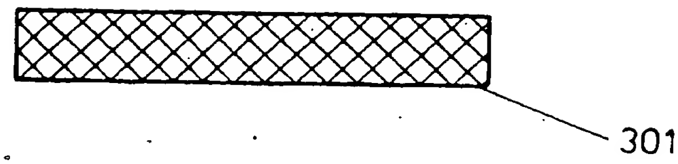

FIG. 7a

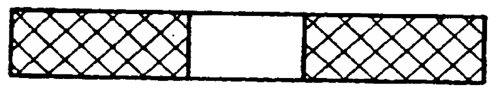

FIG. 7b

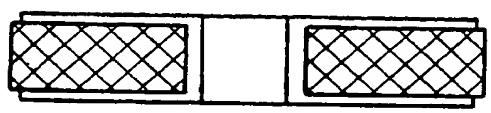

FIG. 7c

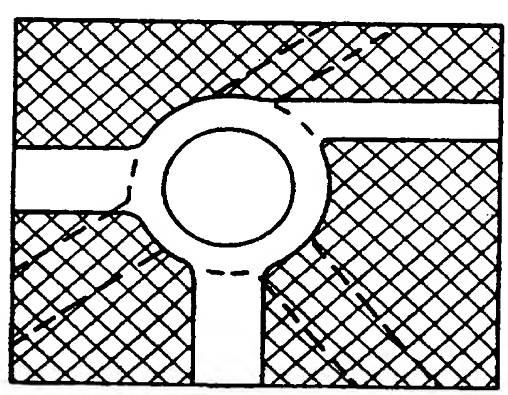

FIG. 7d

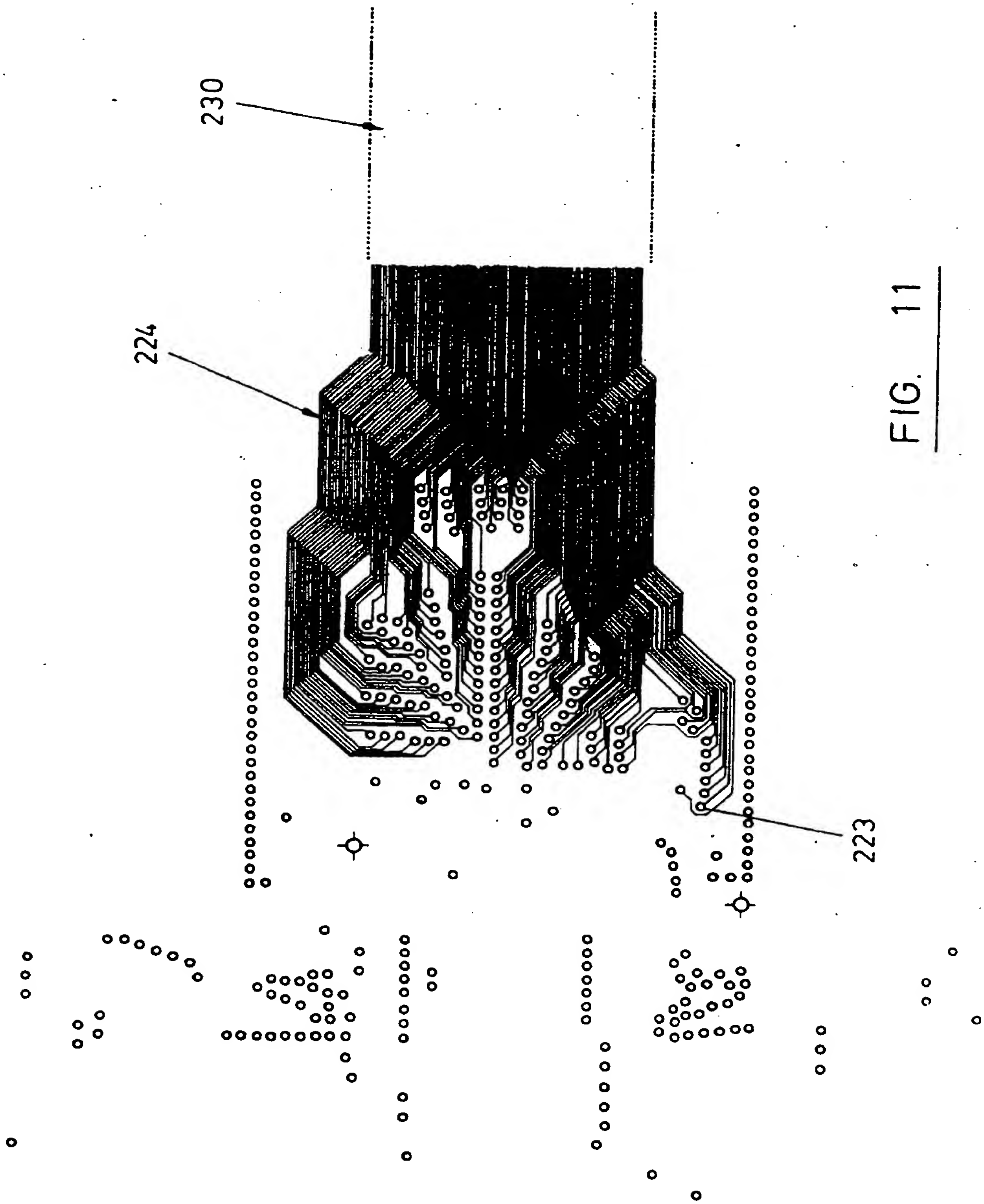

FIG. 11

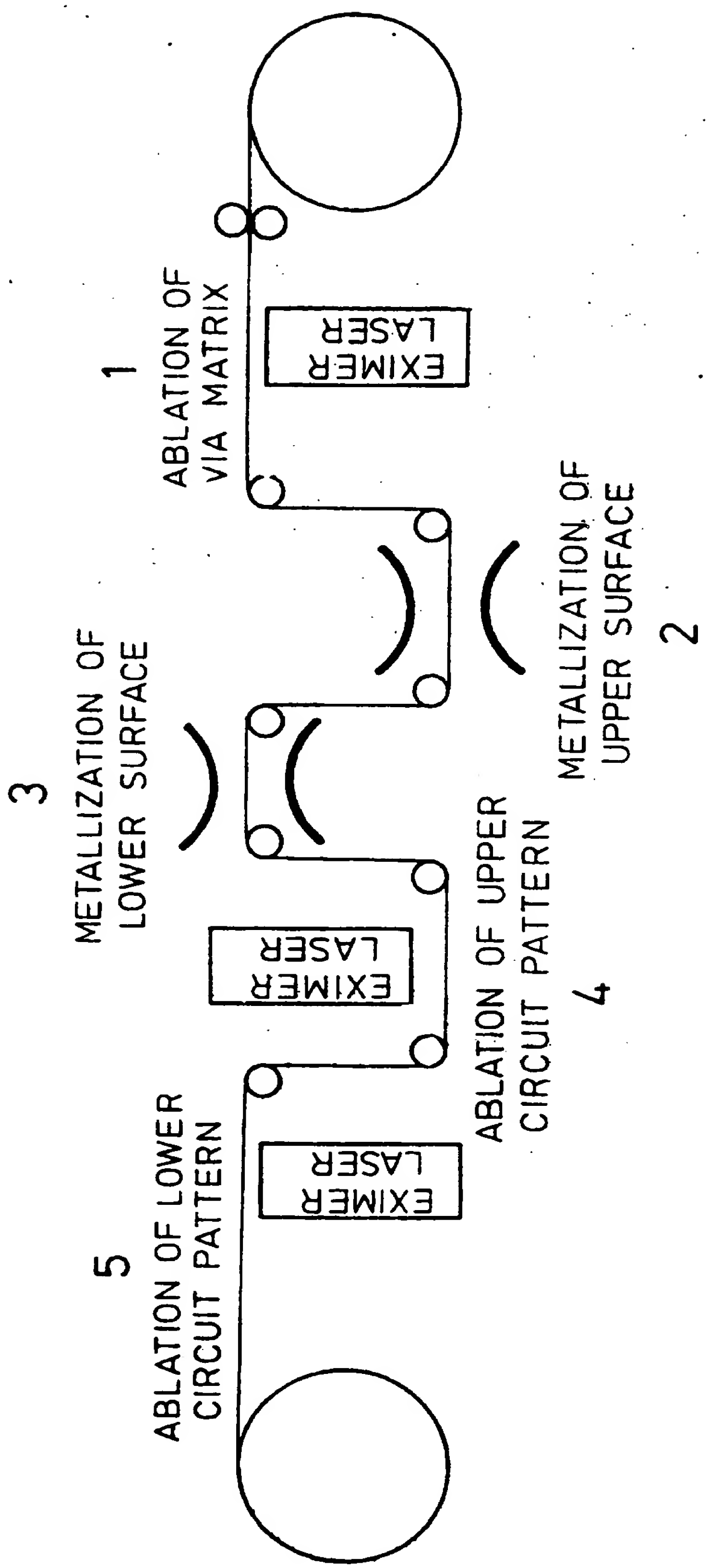
1
ABLATION OF
VIA MATRIX
EXIMER
LASER
METALLIZATION OF
UPPER SURFACE
2
3
METALLIZATION OF
LOWER SURFACE
EXIMER
LASER
ABLATION OF UPPER
CIRCUIT PATTERN
4
5
ABLATION OF LOWER
CIRCUIT PATTERN
EXIMER
LASER

FIG. 8

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 97/02451

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06K9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 862 743 A (SEITZ PETER) 5 September 1989 see abstract; figures 1-14 see column 7, line 16 - line 30 ---	1,2,13, 14,24, 25, 28-30,33
A	US 4 894 635 A (YAJIMA YASUHITA ET AL) 16 January 1990 see abstract ---	1-33
A	EP 0 459 808 A (MARCONI GEC LTD) 4 December 1991 cited in the application see the whole document --- -/--	1-33

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
29 December 1997	08/01/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Granger, B

International Application No
PCT/GB 97/02451

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 373 181 A (SCHEITER THOMAS ET AL) 13 December 1994 see abstract see column 6, line 57 - column 7, line 10; figures 1-5 ---	1-33
A	US 5 483 100 A (MARRS ROBERT C ET AL) 9 January 1996 see abstract -----	1-33

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Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

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International Application No
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